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Cover: To facilitate the election process, many local governments are now using computers in vote tallying. At the request of the Clearinghouse on Election Administration, NBS recently completed a survey of computer use in vote tallying and made recommendations that should help local officials prevent technical and human operational failures. For details see article on page 99.

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

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The Institute for Materials Research
The Institute for Applied Technology
The Institute for Computer Sciences and Technology
Center for Radiation Research
Center for Building Technology
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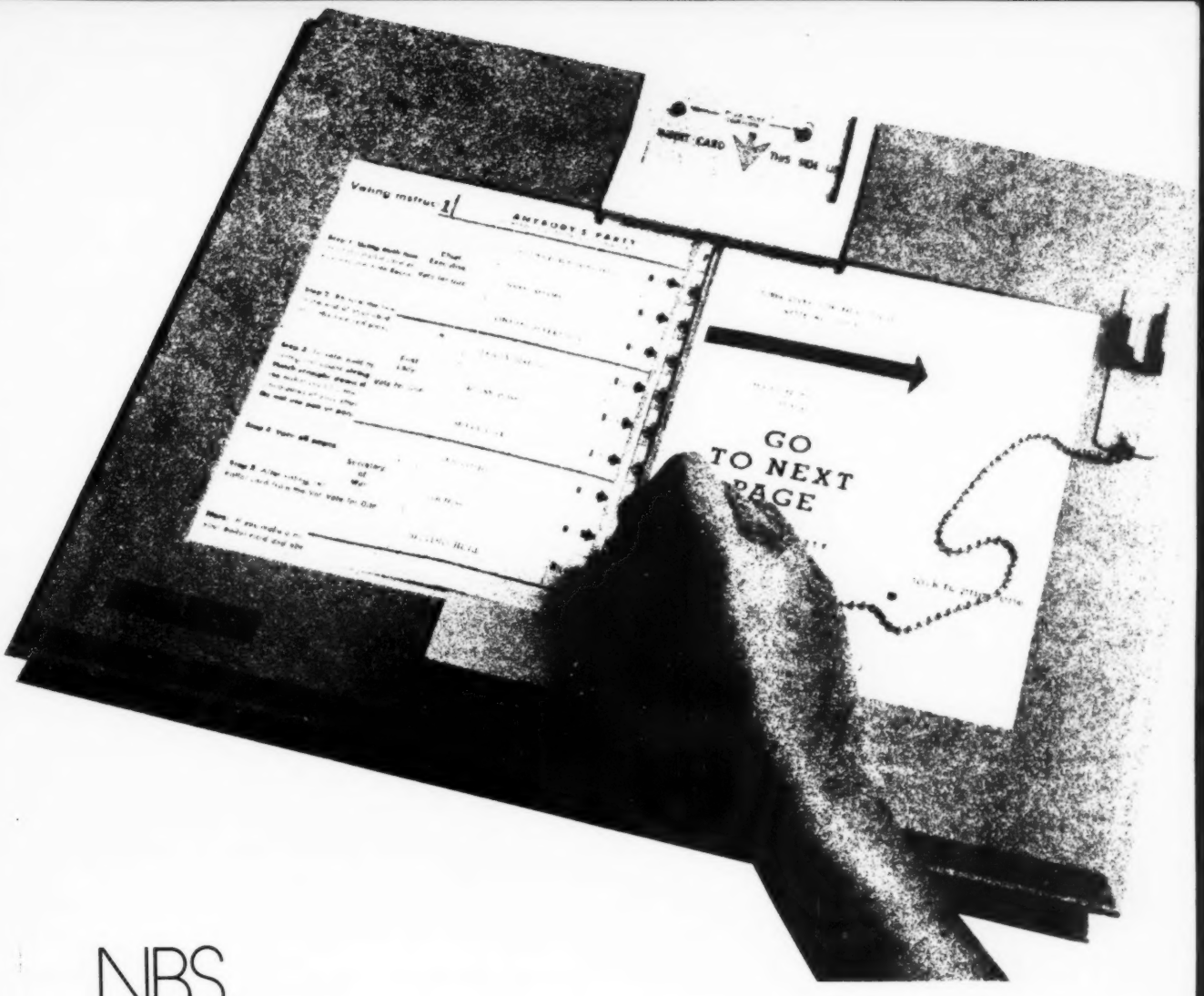

NBS Proposes GUIDELINES for Computerized Elections

• In the Fresno, California, June 1970 primary election, the county failed to allow sufficient time and manpower to prepare the computer program prior to election day. Vote counting could not begin until the program was ready and checked out—87 hours after the polls closed.

• In Redford Township, Michigan, August 1972, an error in the vote-counting computer program was not discovered until the primary election results were almost certified, although the program had previously passed a required "logic and accuracy" test. Initial, incorrect returns reported that a property tax proposition had been defeated by more than 1000 votes

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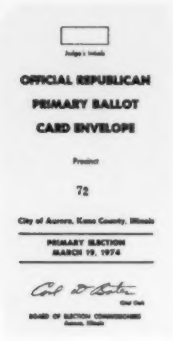

VOTING *continued*

when, in reality, it had passed by more than 100 votes.

• In the District of Columbia, September 1974 primary, the vote-tallying program was changed on election day without prior public notice and without public test, in possible conflict with local election regulations. In addition, difficulties with the computerized ballot-counting system resulted in an order that the approximately 180,000 ballots be hand counted, leaving some election outcomes in doubt for 2 weeks.

ON election day in the not-too-distant future, you may pick up the phone, call a special number, give the necessary identification and proceed to send your vote over telephone lines to a central computer where it will be tallied.

Although "phone-a-vote" is not in official use today, the computer is already a significant part of the election process in this country, especially in the western states of California, Oregon, Arizona and Hawaii. Approximately 30 states have already passed legislation permitting the use of punch-card ballots and computers to tally them.

The widespread use of computers in the election process has caused some concern in Congress and on the part of election officials and the public that computerization of elections could result in a loss of control by authorities and, as a result, increase the possibility of vote fraud.

Prompted by such fears, the Clearinghouse on Election Administration in February 1974 requested that the National Bureau of Standards conduct a year-long study of computer use in vote tallying. The Clearinghouse, at that time a component of the Office of Federal Elections of the General Accounting Office, will be merged into the new Federal Elections Commission.

In developing guidelines for reliable use of computers in vote tallying, Roy G. Saltman, manager of the project at the NBS Institute for Computer Sciences and Technology, examined many types of computerized voting systems and talked with numerous state and local election officials as well as suppliers of computer hardware, software and services.

Elections Studied

Saltman investigated the design of election systems, training of election officials, methods of accounting for ballots, certification and inspection of computer programs, independent audits of the election process, counting center security provisions and vote recounts.

The Clearinghouse intends to publish and distribute Saltman's report nationwide to state and local government election administrators who will then be responsible for implementing the guidelines.

Saltman found that one of the first significant uses of computerized voting was in Fulton and DeKalb Counties, Georgia, in the September 1964 primary election. In the presidential election of 1964, this type of system was also used in Lane County, Oregon, and San Joaquin and Monterey Counties, California. Presently, almost 15 percent of all American voters use punch-cards or other types of machine-readable ballots as their voting medium. Of the 100 largest cities in this country, 16 used computerized voting in the 1972 general election. In Los Angeles County, approximately 2.9 million voters used punchcards to choose a president that year.

The majority of computerized elections do run smoothly, but significant difficulties have occurred in some cases. The General Accounting Office specifically requested that the ICST project team headed by Saltman investigate and analyze those elections in which problems were noted.

No Fraud

While Saltman found no evidence of a deliberate attempt to alter a vote tallying computer program in any of the elections he studied, he did find instances of management failure and insufficient attention to security aspects of computerized voting.

Poor management in such areas as testing and check-out of equipment and procedures prior to the actual voting contributed significantly to problems in computerized elections. Saltman believes that better management procedures will prevent technical and human operational failures that have plagued these elections in the past. Additionally, improved security procedures can help insure public confidence in election outcomes.

In formulating management guidelines for computer use in elections, Saltman recommends that, first, hardware, software and equipment for an election must conform to well-defined specifications and undergo acceptance tests. Programs should be written with the best software engineering techniques.

Supplies, however simple, are important as well. A pencil that makes too light a mark to be sensed may result in an incorrect reading. Ballots

of poor quality may jam in the card reader or be misread.

Second, Saltman recommends that advanced planning for an election include a dry-run of the system, supplies and personnel as well as a site check. Election hardware and software should not be scheduled for use in an actual election, he says, until several months after these have passed acceptance tests to insure that a jurisdiction is not committed to an unacceptable system and that it has sufficient time to select another system.

Third, Saltman recommends developing a contingency plan to cover situations that do not go as initially expected on election day or during the vote tallying on election night. Such a plan should include spare parts, supplies and trained personnel as well as back up computing equipment.

Security Guidelines

Saltman's report also includes guidelines to help elections officials assure the accuracy and security of computerized elections.

To control the security of ballots and materials, Saltman recommends ballot reconciliation. That is, all ballots printed and used should be accounted for in some way. Additionally, for every ballot that goes into the counting system, the number of votes—including overvotes and no votes—should add up. Such vote reconciliation is an added cross-check to see that the computer is not dropping votes. Presently, Oregon is the only state requiring vote reconciliation for computerized elections.

To ensure that election day goes smoothly when computer vote tallying is used, the NBS report recommends that local officials conduct a dry-run of their total system.

Saltman also recommends that all materials used in the voting process be tightly controlled. Also, the precinct number on the ballot should be machine readable to avoid confusion. Mandatory recounts of some precincts in each race will also assure the accuracy of machine-counted votes and retain public confidence.

To maintain the security of the vote-counting programs, the report recommends the elimination of multiprogramming. This means that computers used to count votes

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How Computerized Voting Works

A system used widely today was developed from a concept introduced by political scientists and former government administrator Dr. Joseph P. Harris. Typically, the voter receives a prescored punch-card with a numbered stub attached. The voter inserts the blank card into a holder attached to a loose-leaf-type booklet. The loose-leaf pages are centered over the card, exposing only one column of the card to the view of the voter. As the voter turns the pages, he exposes a different column on the card.

The information on each page includes names of the offices and candidates, identification of the issues and the number of allowable votes for the office. The names of the candidates and issue responses are positioned on the pages so that each clearly corresponds to a different pre-scored location.

Using a stylus, the voter punches the locations corresponding to his choices. After voting, but before depositing the ballot, the stub is removed to eliminate any identification of the individual with his votes. The card is read by a punch-card reader at a counting center, and the information is transmitted into a computer with a specially written program that counts allowable votes. Finally, a computer-driven printer prints out the results.

In a variation of this system, the voter is given a card with the pertinent information printed on it and uses a mechanical punch to indicate his choices. Other systems of machine-readable ballots feature various kinds of markings made by the voter using a dark pencil or a rubber stamp with fluorescent or infra-red reflective ink. The marks are "sensed" by machine and the data is transferred to a computing device for tallying.

In a newly introduced computerized voting system, the voter indicates his choices by activating push-buttons directly on a computing device which summarizes all choices. No ballots are used with this system.

New AIR POLLUTION STANDARDS Developed by NBS

MORE accurate measurements of two major air pollutants, nitrogen dioxide and nitric oxide, will be possible as a result of six new Standard Reference Materials (SRM's) developed at the National Bureau of Standards.

One of the standards, a nitrogen dioxide permeation device (SRM 1629), will provide the most accurate means to date for calibrating equipment and methods used by state and local governments to determine if the levels of nitrogen dioxide in their jurisdictions are in compliance with Federal clean air standards.

The permeation device will help insure that measurements of nitrogen dioxide made by different Federal, state and local government agencies and by industry are compatible.

Also completed is a series of five nitric oxide in nitrogen Standard Reference Materials (SRM 1683-1687) needed by enforcement agencies to monitor compliance of automobile engines with emission standards set forth in the Clean Air Amendments of 1970.

The new nitric oxide SRM's provide a means for the Environmental Protection Agency (EPA), other enforcement agencies and auto makers to calibrate daily working standards obtained from commercial gas manufacturers. The SRM's may also be used by gas manufacturers to help them establish concentration levels of such daily working standards during processing.

The nitric oxide standards complete a series of auto emission SRM's developed by NBS. The earlier three series of SRM's are propane in air (SRM 1665-1669), carbon dioxide in nitrogen (SRM 1673-1675) and carbon monoxide in nitrogen (SRM 1677-1681). These series of SRM's now provide for the first time a means by which automobile emission measurements can be intercompared through a common set of standards.

Development of SRM's for measuring industrial and automotive air pollutants is a cooperative effort by NBS and EPA. Accurate measurements of air pollutants, such as nitrogen dioxide and nitric oxide, are necessary for fair and effective implementation and enforcement of the Clean Air Amendments of 1970, which limit the amount of pollutants that may be emitted by industrial stacks and automobile exhausts.

Millions of tons of nitric oxide are released into the atmosphere each year by industrial and automotive sources. Nitric oxide itself is not considered to be a toxic substance at the concentrations it occurs at in the atmosphere. However, nitric oxide reacts in the air to form nitrogen dioxide which is not only a toxic substance causing respiratory illness at the sub parts-per-million level, but also is involved in the formation of photochemical smog. It is for these reasons that both nitric oxide, and nitrogen dioxide emissions must be controlled. Effective air pollution control depends on accurate measurements of both nitric oxide and nitrogen dioxide.

Nitrogen Dioxide Permeation Device

The nitrogen dioxide permeation device will provide the means for producing a gas stream containing known amounts of nitrogen dioxide for calibrating air pollution monitoring apparatus. It should also prove useful in verifying the accuracy and compatibility of several different air pollution analytical methods and procedures now in use to measure nitrogen dioxide. Furthermore, through the use of this nationally available Standard Reference Material, the consistency, accuracy and compatibility of measurements of this important air pollutant are made possible.

Nitrogen dioxide permeation devices such as this are now available to calibrate air pollution monitoring apparatus.

As was the case for sulfur dioxide, an air pollutant also regulated by the Clean Air Amendments of 1970, it is difficult to supply accurately analyzed mixtures of nitrogen dioxide at desired concentrations in a conventional compressed gas cylinder. Conventional permeation tubes of the type that NBS used successfully for sulfur dioxide (SRM 1625-1627) are not satisfactory for nitrogen dioxide because of their relatively high permeation rates and short lifetimes.

To meet this problem, a specially designed permeation device was developed by Ernest E. Hughes of the NBS Analytical Chemistry Division. The device consists of a glass reservoir to which is attached a short section of FEP Teflon tubing to provide the desired permeation rate. The devices should have a service life of 1 year. Although different in design, the nitrogen dioxide permeation tube is used in a manner similar to that of the sulfur dioxide and other permeation tubes.

The permeation rate of a given nitrogen dioxide tube is constant, with individual rates lying within the range of 0.5 μg/min. to 1.5 μg/min. at 25 °C. The permeation rate from 20 to 30 °C may be calculated from data provided. The certified permeation rate of SRM 1629 at 25 °C is accurate to within ± 1 percent relative; the accuracy is less for permeation rates at other temperatures.

Nitrogen dioxide, alone or in company with nitric oxide, is an important pollutant in both the ambient environmental and the workplace atmosphere. Using an early prototype of the NBS nitrogen dioxide permeation tube, EPA found that the reference method used by states to measure nitrogen dioxide for compliance with Clean Air Amendments of 1970 was in error. As a result of this work, the EPA Administrator withdrew the method on June 8, 1973. New candidates for reference methods are now being evaluated.

Standard Reference Gases

Development of the four series of automotive emission standards resulted from a meeting jointly sponsored by EPA and NBS in 1972. Participants from the automobile industry, EPA and specialty gas manufacturers attending the meeting said that there was a need for standard reference gases for analyzing emissions from automobile exhausts. Such standards are essential for EPA to monitor compliance by industry with the Clean Air Amendments of 1970.

The Clean Air Amendments of 1970 set stringent limits on the amount of certain pollutants—carbon monoxide, nitrogen dioxides and hydrocarbons—that can be emitted from car engines. Eventually, these substances will have to be reduced to 10 percent of the emissions from 1970 cars. The actual date to meet this requirement depends on actions taken by Congress to extend deadlines of the Clean Air Amendments.

Measuring these substances has been a difficult task, however. Different calibrating standards have been used through the industry in measuring automotive emissions, and, as a result, different results have sometimes been obtained by the automobile industry and by EPA, which has ultimate responsibility for monitoring compliance.

The standards that NBS has developed in cooperation with EPA will provide a common reference base for all gas standards used in mobile source emission analysis back to NBS, the central reference laboratory.

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The Treaty of the Metre

1875-1975

The wavelength of light from krypton-86 lamps such as this is now used to define the metre.

THE centenary of the signing of the Treaty of the Metre, a decisive event in the history of measurement, is being celebrated this year by ceremonies in Paris under the auspices of the International Committee on Weights and Measures and by special events in the United States.

At the National Bureau of Standards, the occasion is being marked by several activities including the opening of exhibits on the Metric System and the Treaty of the Metre and a conference of educators on the teaching of metric units.

Strengthened Metric System

Signed May 20, 1875, by 18 nations, including the United States, the Treaty of the Metre strengthened the scientific basis of the Metric System and consolidated its position as the leading international system of measurement. Although by 1875 the Metric System was in full use in about a dozen countries, the Treaty in effect recognized the primary international status of that system.

It did this by setting up the International Bureau of Weights and Measures which had custody of the prototype standards of the metric units, to which all metric measurements were to be traceable; served as center for the development of international agreements regarding weights and measures; and, besides doing research of its own, acted as clearinghouse and focal point for research on standards and measurement elsewhere in the world.

Perhaps the only other event of equal or greater importance for the future of the Metric System was the working out of its original design and philosophy, implemented and largely developed in France at the end of the 18th century, that envisioned a simple and coherent system of units based on physical phenomena equally accessible to all people.

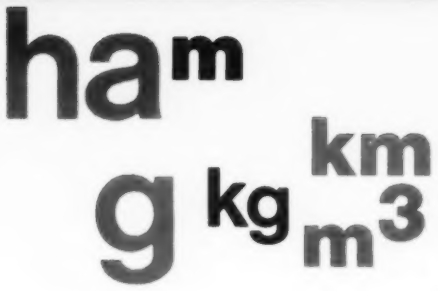
Birth in France

Not entirely by accident, the Metric System was born in France during the French Revolution that began in 1789.

Certainly, few countries needed weights and measures reform more than France did at that time. Its local museums today are full of specimens of weight and capacity standards, for example, which show that literally hundreds of different sets of units were in use, each of them rooted in the habits of some particular region or occupational group.

And France had the talent to cope with the problem, for its science was then approaching one of its great peaks of creativity. It could and did call on first-rank scientists like Laplace, Lavoisier, Legendre, Condorcet, Borda and Monge to draw up the first groundplan for the system we now call Metric.

Yet the idea of introducing a more rational and uniform system of weights and measures had been crystallizing for at least two centuries, in other countries as well as in France. Even in the newly independ-



ent United States the problem was given much attention, notably by Thomas Jefferson.

As early as 1585, the use of decimal scales (based on multiples of ten) was proposed by the Dutch mathematician and physicist, Simon Stevin. In 1670 another key metric concept was proposed by the French churchman, Gabriel Mouton, who suggested that the unit of length be based on the size of the earth, in particular on the length of a meridian quadrant—the distance from the north pole to the equator.

After several abortive attempts to put such ideas into practice, the turbulence of a major social upheaval finally opened the way to a successful effort.

The breakthrough came in 1790 when Talleyrand presented, and the National Constituent Assembly adopted, a proposal to simplify and unify the system of weights and measures. Even so, it was 50 years before the new system was definitively accepted by the French people.

As drawn up by the above-mentioned scientists, acting as a committee of the Paris Academy of Sciences, the essentials of the plan were: (1) to use only decimal scales, (2) to make the unit of length, called the *metre*, equal to one ten-millionth of the meridian quadrant and (3) to make the unit of mass, the *gram*, equal to the mass of one cubic centimetre of water at the temperature of maximum density. The unit of capacity, the *liter*, was defined as the volume of a cube 10 centimetres along an edge.

Using the result of measurements by astronomers Delambre and Méchain, a prototype metre was constructed—a platinum bar with squared-off parallel ends, its length equal to one ten-millionth of the meridian quadrant. Based on measurements of the density of water by Lavoisier and Haüy, a prototype kilogram was constructed about the same time—a platinum cylinder with mass equal to that of 1,000 cubic centimetres of water at maximum density.

In 1799, these prototype standards became the basis of the mandatory system of weights and measures in France. Deposited in the Archives de la Republique, they were known as "the metre and kilogram of the Archives."

At last the Metric System had a solid beachhead, an achievement that owed as much to political sagacity and persistence as to scientific vision. Speaking for the latter, Lavoisier declared that "Never has anything more grand and simple, more coherent in all its parts, issued from the hand of man."

The Treaty of the Metre

The potential for international expansion of the Metric System was inherent in its very concept.

After 1840, movements to adopt metric units in other countries developed rapidly. By 1870 it had spread from France to the Netherlands, Belgium, Italy, Portugal and five smaller nations.

Scientists took to the new system almost automatically and it was soon in nearly universal use by them everywhere in the world. In 1867, the International Geodetic Conference at Berlin recommended creation of an international bureau of weights and measures.

Growing international trade and increasing sophistication of technology also worked in its favor. The need for international unification of measures was forcefully proclaimed at the industrial world fairs and expositions of the 1850's and the 1860's.

These forces were brought to a focus in 1870-71, when scientists from 30 countries met to consider how best to improve and broaden the international basis of measurement. This Committee of the Metre, as it was called, urged establishment of an international bureau of weights and measures and construction of new prototype standards of higher precision.

Three years later these recommendations were given official sanction by the Diplomatic Conference on the Metre, which drew up the "Convention of the Metre," now better known as the Treaty of the Metre.

On May 20, 1875, the signatories, among them the United States, agreed to set up and maintain at common expense a scientific and permanent International Bureau of Weights and Measures. Located at Sevres, just outside Paris, the International Bureau is a tiny international enclave within French territory.

Developing Prototype Standards

The International Bureau's first job was to construct prototype standards of the higher level of precision required and made possible by the advance of science. The new prototypes, it was decided, would have as nearly as possible the same length and mass, respectively, as the metre and kilogram of the Archives "in their existing condition."

A highly rugged platinum-iridium alloy was the material used. Ex-

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BEYOND X-RAYS

Seeing Beneath the Surface with Neutron Photography

TRY to imagine taking a picture of an object through 10 centimetres (4 inches) of solid lead. You couldn't do it with an ordinary camera or even with X-rays. But you could with neutron radiography, a powerful nondestructive evaluation technique that can be used to detect corrosion in aircraft assemblies, locate hard-to-detect tumors in bone and tissue, detect flaws in explosive devices, inspect nuclear fuel rods and determine moisture distribution in soil.

What is this versatile tool that can take clear pictures through both lead and tissues? "It's a technique much like X-rays, except instead of a beam of X-rays you use a beam of neutrons to get your image," explains National Bureau of Standards' research physicist Harold Berger, one of the pioneers in the development and application of neutron radiography. "The major advantage of neutron radiography over X-radiography is that neutrons make it possible to see things that X-rays reveal poorly or not at all." For instance, neutron radiography can detect minute contaminants which can cause intricate castings and turbine blades to fail—something that X-rays miss.

Because of this special advantage as a nondestructive test method, neutron radiography is being studied at NBS by Berger and his associates, Martin Ganoczy and Dr. Vernon Meyers, in the Institute for Materials Research. Other nondestructive test methods under investigation at NBS are X-radiography, ultrasonics, acoustic emission and analyses of wear particles. These studies, which are part of the Bureau's effort to improve nondestructive evaluation technology in the United States, are aimed at improving standards and test methods and promoting wider application of the methods.

Striking Difference

Most people who have visited a physician or a dentist are familiar with X-rays; neutron radiography works in much the same way. Basically, the object to be examined is placed in a beam of neutrons, which are subatomic particles without an electric charge. The neutron beam, after passing through the object, carries information about the internal structure and composition of the object in the form of spatial variation of the transmitted neutron beam. The film is then developed like a conventional X-ray film.

Despite the similarities between X-ray and neutron methods, there is a striking difference between a neutron radiograph and an X-radiograph of the same object. This difference occurs because neutrons interact only with the nucleus of the atom, whereas X-rays interact with the electrons orbiting around the atom. Interactions of neutrons with atoms are thus independent of the density of the element, and, in fact, vary randomly with different elements and even between isotopes of the same element. One advantage of this property is that neutrons penetrate many metals such as steel and lead more easily than do X-rays. Also, materials containing hydrogen, lithium, boron and cadmium are almost opaque to neutrons which make it possible to observe plastic explosives or fluid components encased in metal.

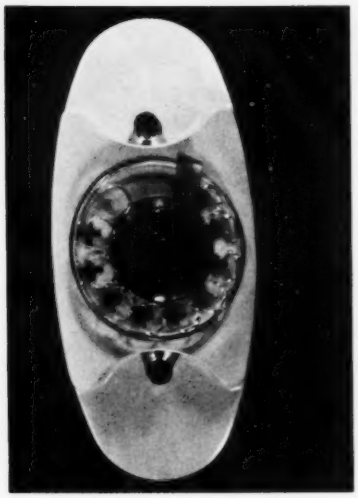
Another serious problem in metals which neutron radiography detects easily is "hydrogen embrittlement." This occurs when hydrogen gets into metal and forms a new structure with the metallic atoms, a condition that causes the metal to fracture easily. In addition, because neutrons can activate materials, modified techniques called "transfer methods," can be used to radiograph highly radioactive items such as nuclear fuel elements, something that is impossible with ordinary X-ray techniques.

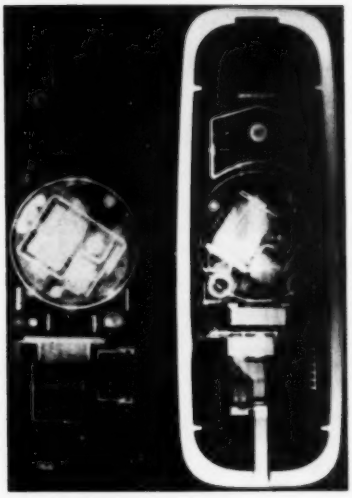
Applications

Although neutron radiography is a relatively new method compared to X-radiography, it is already being applied to practical inspection problems in a number of industries and in the research community. Recently, NBS and the American Society for Testing and Materials cosponsored a meeting at NBS where more than a hundred people heard about recent advances in neutron radiography applications, among them:

- Neutron radiography has been applied successfully in aerospace com-

Harvey Berger inspects neutron radiograph of ball-point pen.





As the pictures of the telephone show, there is a striking difference between a neutron radiograph (near left) and an X-radiograph (center).

Photo courtesy Sandia Laboratories

ponents to detect flaws in composite materials and hydrogen embrittlement in metals.

- Neutron radiography has been used to improve the reliability of all types of electronic components by detecting internal flaws and internal contaminants.
- The aircraft industry is beginning to use neutron radiography to detect corrosion in a variety of aircraft assemblies, especially where the corrosion is hidden behind thick metallic structures and X-radiography cannot be used.
- Manufacturers of explosive and pyrotechnic devices use neutron radiography as an effective tool to insure product integrity and quality. Explosive charges in these devices are readily visible in the neutron radiograph and can therefore be inspected for gaps, moisture, cracks, voids, high and low density areas and other defects that can prevent proper functioning.
- Neutron radiographs are routinely used to inspect all types of nuclear fuel and cladding, poison distribution, burnup rates, control rods and nuclear instrument components. This type of inspection will become even more important in the next 10 years when nuclear power is expected to supply about 25 percent of all electricity in the United States. (A 1-year shutdown of a nuclear power plant because of component failure can cost over $100 million and deprive an area of its full power requirements.)
- In complement with X-radiography, neutron radiography of a pathological specimen after surgery can be used to determine if all of a malignant tumor has been removed from bone.

Standards Needed

Despite the increasing use of neutron radiography for practical purposes, Berger explains that it is not always certain that a radiographic procedure will really visualize all the details sought in an inspection, even when an image quality indicator appears on the radiograph. An image quality indicator is designed to assure that a radiograph has been taken properly. However, several different sets of radiographic image quality indicators exist in the United States and the rest of the world, Berger says, a fact that creates confusion in specifications in this country and in matters related to international trade.

Working with the American Society for Testing and Materials, Berger and his colleagues are working on standards that will lead to improved quality of neutron radiographs. The work at NBS is made possible by the Bureau's 10 megawatt nuclear reactor, which provides a source of neutrons directly, as a by-product of nuclear fission. (Particle accelerators produce beams of high energy charged particles, usually protons, which can give rise to neutrons if they are directed against a suitable target material such as lithium or beryllium).

The standards work involves characterizing neutrons beams from the point of view of beam divergence and gamma ray content. Divergence of neutron beams can cause fuzzy images; the presence of gamma rays in a neutron beam may be important depending on the material that is being examined. The research should result in two new image quality standards, according to Berger. Another cooperative effort with ASTM will result in a "recommended practice" for neutron radiography. This will be a procedural document that will outline recommendations and steps to follow when making radiographs under different conditions and for different applications.

Researchers at NBS are also trying to develop better detectors and scintillators for neutron radiography and "real-time" television methods. The latter method could be used to inspect items on assembly lines or to follow processes such as the flow of gasoline in a carburetor to determine how efficiencies could be improved. The NBS reactor is also a resource for researchers from a number of industries, government agencies and universities to carry out collaborative

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A Look at The OZONE

THE ozone layer of the stratosphere, beginning 10 to 15 kilometres up from the earth's surface, protects all life from the sun's harmful ultraviolet rays. Occasionally penetrated by a high-flying jet near the North Pole, the stratosphere and the ozone layer have not attracted much concern until recently.

Now, however, scientists are warning that the ozone may be threatened by nuclear weapons, rockets and the space shuttle, supersonic transport planes (SST's) and the most unassuming assailant of all—the common aerosol spray can. National Bureau of Standards chemists Dr. David Garvin and Dr. Robert Hampson have been following recent scientific research linking possible destruction of part of the ozone layer with widespread and growing use of aerosols.

"The predictions that have been made so far strongly suggest that this is potentially a very serious pollution problem," Garvin commented. "It must be studied in detail before we can say for sure."

It's not the hair spray, paint or deodorant dispensed in aerosol cans that threaten the ozone layer—it's the gas that propels these and other liquid products at the touch of a fingertip. Some of these propellants are called chlorofluorocarbons; they are also referred to by a widely used trade name, Freon. As one by-product of an advanced and convenience-oriented society, these gases have been released into the atmosphere in increasing amounts in recent years through the increasing use of aerosols. The gases are also widely used as refrigerants and in many industries.

Chlorofluorocarbons are very inert; they do not dissolve in water, they are not known to react rapidly in the lower atmosphere. Consequently, when released into the atmosphere by push-button aerosol devices, they accumulate and slowly diffuse upwards into the stratosphere.

Since about 1970, scientists have suggested using these accumulated propellant gases to trace movements of large air masses. But in early 1974, Dr. F. S. Rowland and his associate Dr. Mario Molina of the University of California at Irvine suggested that ultraviolet light in the stratosphere could photodissociate these gases, causing them to release free chlorine atoms, which in turn could break down the ozone.

Several other studies, notably one by the National Academy of Sciences (NAS), have warned that reduction of the ozone layer could lead to increased incidence of skin cancer, adverse effects on world crops and changes in global weather patterns. The ozone problem has been studied intensively since 1971, mainly to determine the effects of aircraft exhaust on the stratosphere. Recently the Federal government set up an interagency task force to study the chlorofluorocarbon problem and related issues. Commerce Department economists and atmospheric scientists will contribute to the task force's first public report, slated for completion in June 1975.

At the first public meeting of the

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NE Problem

Interagency Task Force on Inadvertent Modification of the Stratosphere (IMOS) on February 27, 1975, Rowland said that if the current rising trend of spray can use continues, the ozone layer will be depleted 10 to 40 percent 50 years from now, and the effects on humans, crops and climate could be "catastrophic."

While scientists disagree on the implications of existing evidence, Garvin and Hampson believe the problem is potentially a big one. "According to the predictions, if we continue to use chlorofluorocarbons at our present rate, we'll see a small but noticeable depletion of the ozone layer in the next decade," said Garvin. "If we accelerate our rate of usage, scientists predict more substantial decreases in ozone—decreases that will last a long time."

"A unique feature of the problem is the long time delay between emission of chlorofluorocarbons down here and their maximum effect 10 to 20 years later in the stratosphere," remarked Hampson. "Even if we stopped using aerosols today, the predictions are that we wouldn't feel the maximum effect of the ones we've already used for at least a decade."

Among all the possible effects of ozone depletion perhaps the most alarming effect would be increased incidence of skin cancer. Scientists have estimated that a 5 percent depletion of the ozone layer would cause more than 8,000 additional skin cancer cases in the United States each year. Skin cancer is usually curable, but treatment is expensive and unpleasant. It attacks fair-skinned Caucasians most often, and generally appears in persons over 30 years old.

Serious effects on crops, forests, deserts, insects, animals, ocean life and materials have also been predicted. The climatological effects are complex and not yet understood. Some scientists say that increased ultraviolet light will melt polar ice. Others say that ozone depletion will bring on a new ice age.

"These predictions are very suggestive," said Garvin. "It's clear that

turn page

we need verification of these predictions and better data upon which to base decisions."

Garvin explained that study of the stratosphere involves computer models that predict what will happen to the ozone layer, as well as measurements of existing concentrations of given substances in the stratosphere. "In order to determine what will happen," he said, "scientists attempt to build in a computer a model of the complex meteorology and chemistry that occurs in the stratosphere.

"Predictions made on the basis of these models depend to a large extent on the validity of the data fed into them, and knowledge of the chemistry that can occur," he added.

Garvin and Hampson are producing tables of data on how fast certain chemical reactions take place in the stratosphere. When incorporated in a computer model of the stratosphere, their tables can help scientists predict what will happen to the stratosphere 10, 20, or 50 years from now.

These chemical kinetics tables, which combine carefully evaluated data from over 100 laboratories with data supplied where needed by NBS, are jointly sponsored by the Department of Transportation and the NBS National Standard Reference Data System.

Another NBS group, the Office of Air and Water Measurement, is interested in measuring existing concentrations of propellant gases in the stratosphere. Dr. Radford Byerly, Air Program Manager, said, "We need to know not only how fast the reactions take place, but how much of each substance is up there."

"You're talking about measuring concentrations of one part in 10 billion," he said. "When samples are brought back to the lab after being taken in the stratosphere, there's so much chlorofluorocarbon gas in the lab itself that the sample may become contaminated."

Byerly said he hopes NBS will be able to provide standard reference materials or standard samples of minute concentrations of chlorofluorocarbons, or, alternatively, develop new measurement methods that will minimize error caused by contamination.

In addition, scientists in the NBS environmental chemistry section are studying the photochemical decomposition of chlorofluorocarbons. Dr. Arnold Bass is measuring the absorption coefficient of chlorofluorocarbon molecules—that is, how much light the molecules absorb—in the ultraviolet light region. Dr. Pierre Ausloos and Dr. Richard Rebbert are determining the gas molecules' photo-efficiency—that is, the extent to which chlorofluorocarbons decompose under ultraviolet light to produce free chlorine atoms, chlorine molecules and other reactive fragments.

Dr. Marilyn Jacox is using the matrix isolation technique, which involves freezing very low concentrations of gases at very low temperatures, in order to produce and characterize the free radicals and ions formed from chlorofluorocarbons.

Knowing how chemical reactions occur in the stratosphere as well as knowing what chemicals have accumulated there will help scientists determine the extent of the problem. "If it's a problem at all, it's a big one," said Byerly. "If Rowland's worst predictions are true, then we ought to do something."

One thing scientists now know is that chlorine atoms, released from chlorofluorocarbons by ultraviolet light, react with ozone in a "catalytic cycle." In this type of cycle, ozone is changed to oxygen and chlorine is re-formed. The new chlorine atoms can continue breaking down the ozone faster than ozone can be replaced by natural processes.

This same type of catalytic cycle also occurs with nitrogen oxides, such as those released into the stratosphere by the SST. This knowledge formed the basis of anti-SST arguments a few years ago, and recently some scientists have noted that increasing use of nitrates as fertilizers may pose an additional threat.

Chlorine may also be reaching the stratosphere through its use as a water purifier and its presence in compounds used as refrigerants, dry cleaning solvents, foaming plastics, and other products. At the first IMOS public meeting, one scientist said that bromine, which could be released by organic bromides used in plastics and in cropland fumigation, depletes ozone so effectively that it could be used as a weapon.

Despite these predictions, the danger may not be as great as some scientists say it is. "The ozone layer may be in equilibrium with large natural sources of chlorine, such as the ocean," said Byerly. "If it is already maintaining itself against a natural chlorine source, then maybe adding a small additional amount of chlorine won't make any difference."

All in all, the problem is a new one and is full of speculation. "No one would have foreseen a problem like this in 1965," said Garvin. "It wasn't until about 1970 that anyone meas-

continued on page 119

HIGHLIGHTS

Performance Criteria

Performance criteria for solar heating and cooling systems, which will be used by the Federal Government to prove the practicality of heating and cooling American homes with solar energy, are now available.

The criteria were developed by NBS under the direction of the Department of Housing and Urban Development (HUD). The "Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings" will be used by HUD as a basis for selecting designs of these systems for residential dwellings in an open competition.

Copies of the criteria may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at $1.90 a copy. Use Stock No. 0324-01043.

Computer Networking

A symposium on "Computer Networks: Trends and Applications 1975" will be held June 18, 1975, at the NBS Gaithersburg, Md., campus. Sponsored by NBS and the IEEE Computer Society Washington Chapter, the symposium will explore the planning, implementation, evaluation and use of large and small scale computer networks. Important technical advances in networking will be reported and the progress of existing networks will be reviewed.

For information, contact Computer Networks, P.O. Box 639, Silver Spring, Md. 20901. Telephone: 301/439-7007.

Environmental Specimen Bank

NBS is jointly sponsoring with the Environmental Protection Agency a 5-year project to establish a National Environmental Specimen Bank System, which will include carefully taken and preserved samples for the determination of such substances as trace elements and trace organic compounds, as well as radionuclides and microbiologically significant samples. The availability of such samples in the future will allow the rapid evaluation of the impact of presently unknown or unsuspected environmental substances.

Gaseous Fuels

An NBS study recommends the use of safety precautions, such as ventilation and warning systems, to reduce the hazards of explosion associated with accumulated combustible gases which may result when gasoline-powered autos are converted to operate on gaseous fuels, such as hydrogen or methane. The study also notes that methane and hydrogen gases appear equally safe as vehicular fuels if used in properly designed vehicles.

Titled "Efflux of Gaseous Hydrogen or Methane Fuels from the Interior of an Automobile," the study is available as SD Catalog No. C13.46:666 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The price is $1.10.

Design Concepts

NBS is developing a comprehensive life/fire safety model, primarily for health care facilities. The model will provide the means by which building designers and code officials can rationally select building elements which have the greatest safety and cost effectiveness.

The program will integrate into the model results from research studies of five elements thought to be important in reducing loss of life from fire in buildings: human behavior in fire emergencies, smoke control systems, fire and smoke detectors, automatic extinguishment systems and alarm and communication systems.

Laboratory Thermometers

Accurately calibrated thermometers intended primarily for use in the clinical laboratory are now available as Standard Reference Materials (SRM's) from NBS. These SRM's were developed for use in clinical laboratory work such as enzymatic reactions, pH measurements and blood-gas analyses, for which accurate temperature measurement is required.

Information on the SRM's may be obtained from the Office of Standard Reference Materials, B311 Chemistry Building, NBS, Washington, D.C. 20234.

Radiation Safety Standard

A new safety standard, which specifies design and procedures of installations used typically in industrial radiography, was published recently by NBS under the auspices of the American National Standards Subcommittee N43-5. The standard is intended to serve as a general guide for the safe use of X-ray and sealed gamma-ray sources for non-medical purposes.

The standard can be ordered as SD Catalog No. C13.11:114 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 90 cents. □

ETIP, Utility Commissions and Policy Experiments

THE National Bureau of Standards' Experimental Technology Incentives Program (ETIP) has selected four state public utility commissions for experiments applying computerized data and analysis techniques to improve utility rate-setting processes and regulatory policies.

The proposed experiments focus on reducing "regulatory lag" (basing rates on outdated information), analysis of company rate-structures, surveillance of company rates and performance and analyses of new utility plant forecasts, utility company performance and long-range economic planning.

Dr. Jordan D. Lewis, director of ETIP, said potential contractors may run up to six separate experiments with the public utility commissions of California, Ohio, North Carolina and New York. The program will be managed jointly by ETIP and the Federal Power Commission (FPC).

States were selected on the basis of representative size, computer experience, willingness to cooperate and geographical location. Contractors must secure approval of each commission on specific projects, said Philip J. Harter, chief of ETIP regulatory programs. Other states may be proposed with written consent of the state's utility commission, said Robert Berman, FPC project monitor. The formal invitation for bids was published Thursday, April 24, in Commerce Business Daily.

The Experimental Technology Incentives Program at the National Bureau of Standards seeks new ways of improving productivity in government and industry. Its experiments are conducted in cooperation with agencies which have the job of putting new policies into effect, said Lewis. The ETIP experiments concentrate on four areas: regulatory policy, procurement policy, small business policy and civilian research and development policy.

New computer applications for public utility commissions are the latest ETIP experiments with energy-related projects, said Lewis. With ETIP "seed money," experiments have assisted Federal agencies in the purchase of more than $14 million worth of energy-saving window air conditioners, kitchen ranges, hot water heaters and refrigerator-freezers for use in Federal Government facilities.

Similar ETIP assistance has helped demonstrate that the time needed to write draft-standards for nuclear power plants can be reduced from 1 year to a period of about 1 month. Two such standards—the evaluation of man-made and natural hazards at proposed reactor sites and the criteria for evaluating the qualifications of power plant operators—have received draft approval. The standards now await final approval.

Lewis said results of the utility commission experiments should indicate new ways to improve the regulatory process in other states besides the ones selected. "The energy shortage has put tremendous pressures on both government and utilities to improve performance," said Lewis. □

Instrument Evaluates Wear of Dental Filling Materials

AN apparatus which reduces the time needed to determine the wear durability of dental restorative materials from several years in the clinic to several days in the laboratory has been designed and built by scientists at the National Bureau of Standards.

The device simulates conditions in the human mouth and measures the resistance to wear of restorative materials and is expected to aid in the development of better and longer-wearing materials.

George Dickson and Dr. Joseph Powell of the NBS Dental and Medical Materials Section described their use of the apparatus in comparing the wear properties of an amalgam and a composite restorative material at the American Association for Dental Research meeting in New York

City. Dr. Powell is an Air Force Guest Worker at NBS.

There has been no generally accepted way of measuring the resistance to wear of materials used by dentists to fill cavities. Many laboratory wear test procedures have been reported, but the results of these tests often do not correlate with the results of actual clinical observations over a period of years.

The wear generating device in the apparatus is a "pin-on-disk" configuration. The disk is made of the material to be tested. It is mounted at the center of a turntable. The pin is a ground cylinder of human enamel which is held in contact with the disk by means of a pivoted arm.

The pin, which rests slightly off-center on the specimen, is loaded to a stress that realistically matches the chewing pressure in a human mouth. When the turntable rotates, the pin wears a circular track in the sample.

The measuring system in the apparatus consists of two parallel beams, one over the other, with sapphire-tipped points positioned so that one point lies in the wear track and the other on an adjacent, nonwearing (or reference) portion of the specimen. The rate of wear is determined by the measurement of the depth of the wear track.

The data acquisition system consists of a digital voltmeter which receives a signal from a linear variable differential transformer (LVDT) coil attached to the upper beam of the measuring system and transmits it as digital binary code. The data are recorded and the depth of the track is printed out and punched onto tape to be fed into a computer for analysis.

When evaluating a material, the surface of the sample is first allowed to "run-in" sufficiently to establish the wear track. This takes approximately 6 hours for amalgam and 3 hours for composite materials.

During testing, the turntable rotates at a speed of 27 rpm for 30 minute periods as the sample is continuously flooded with distilled water at a temperature of 37 degrees C. The measuring pins are not in contact with the specimen at this time.

At the end of each cycle, the turntable speed reduces to 4 rpm, the water flow stops, and the two measuring points automatically lower into contact with the sample to take depth measurements at 10 equally spaced positions around the circumference of the wear track. Testing continues for 24 hours for each sample.

Dickson and Powell report a marked difference in the wear resistance of amalgam and the composite restorative material. The loss of volume in the composite material was approximately two times that of the amalgam. The system ranks the wear of these two materials in the same order as did previous clinical evaluations.

The availability of these clinical evaluations was the reason for the choice of amalgam and composite materials for the first tests with the new device. The apparatus can also be used for studying other materials.

The wear generating and measuring instrument, still in the preliminary stages, has great potential in aiding in the development of new and better dental restorative materials, especially if it is used in testing these materials before they reach the clinical stage.

This research was supported in part by an interagency agreement between NBS and the National Institute of Dental Research of the National Institutes of Health. □

The wear-generating system in the NBS apparatus creates a circular wear track in the sample of material being tested.

Surveillance Camera Guideline to Help Cut Thefts

REDUCING the estimated $3 billion in shoplifting losses suffered annually by retailers and alleviating additional hardships imposed by armed robbery and employee theft is the aim of a guideline now available from the National Bureau of Standards.

The *Selection and Application Guide to Fixed Surveillance Cameras* is a Justice Department publication prepared by NBS' Law Enforcement Standards Laboratory (LESL) in cooperation with the Naval Surface Weapons Center. The guide appears under the aegis of the National Institute of Law Enforcement and Criminal Justice (NILECJ), Law Enforcement Assistance Administration (LEAA).

"Do I Need Fixed Surveillance Photography?" and "How Much Will It Cost?" are among key questions examined from retail business' and local bank manager's standpoints.

The guideline provides a basis for business decision-makers to analyze their own security needs and plan an appropriate course of action. For those choosing fixed surveillance cameras as an effective solution, the guideline offers pointers on conducting site surveys, considering camera placement and, in general, blueprinting the overall surveillance program. It also discusses, where applicable, the use of cameras against bad-check passers.

Topics covered in the booklet include:

- Still, motion pictures or television systems.
- Continuous or demand operation.
- Film sizes, types, handling, storage and processing.
- Camera location.

Improved protection for banks may be provided by managers who "bone up" on fixed surveillance camera by using the Selection and Application Guide prepared by NBS for the Justice Department.

- Lens selection, aiming and focusing.
- Lighting and exposure.
- Maintenance.
- Techniques for obtaining "a good photograph of a crime being committed," usable as courtroom evidence.

The *Selection and Application Guide to Fixed Surveillance Cameras* (NILECJ-GUIDE-0301.00) is one of a series of guideline publications being prepared by LESL as part of a program initiated under the Omnibus Crime Control and Safe Streets Act.

Order printed copies PREPAID at 85 cents a copy and by GPO Stock No. 027-000-00281-1 from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Foreign remittances must be U.S. exchange and include an additional 25 percent of the publication price to cover mailing costs. □

NBS Tests "Little Box" That Speeds Police Communications

IN more and more cites, officers in police prowl cars are letting their fingers do the talking.

In the front passenger seat is a little box with a keyboard and an upright screen or a printout device—a "mobile digital communications terminal"—that enables the sending or receiving of messages in seconds rather than minutes.

Performance tests and experiments with the digital terminals are being conducted by the National Bureau of Standards. The test series, using equipment supplied by leading manufacturers, is under way at the Bureau's Electromagnetics Division in Boulder, Colo.

The work is part of a Justice Department program for which the NBS Law Enforcement Standards Laboratory (LESL) provides technical assistance. This program is sponsored by the National Institute of Law Enforcement and Criminal Justice (NILECJ) of the Law Enforcement Assistance Administration (LEAA).

The types of terminals being evaluated include:

1. Mobile teleprinters for one-way digital message flow from dispatcher to cruiser, with messages from mobile units transmitted by voice.

2. Status boxes for a limited number of standardized "status" messages, codes and emergency alarms, with voice communication for inquiries and dispatcher-originated messages.

3. Full two-way units combining a typewriter-like keyboard, status keys and a display screen—eliminating the need for voice communication except in emergency situations.

A principal concern of the LESL specialists is the compatibility of this digital equipment with current operating police radio systems. Technical considerations of major interest include signal transmission time, supply voltage level, error rate and display readability. Keyboard preference tests to determine the most favorable arrangement of keys for most users are also in progress at NBS.

Field reports from an increasing number of police jurisdictions suggest that "all in the day's work" takes on new meaning for the patrol car officer when digital terminals are in use. Each 24-hour caseload typically runs the gamut from trivialities and false alarms to serious crime and genuine emergency—from "dog case" to "armed robbery."

Any sharp reduction in time on the air required for responding to calls and obtaining information significantly increases police effectiveness. West Palm Beach County (Fla.) police, for example, reported enhanced capacity to handle a large number of calls—the tally rising from 500 to 70,000 "data base inquiries" a month as a result of digital terminal communication.

The digital system also contributes to greater safety for the patrol officer, since less cluttered communication lines allow help to be summoned faster.

LESL's role is to provide law enforcement authorities with technical guidance for the evaluation and selection of equipment in this and other major police technology areas. Established by an interagency agreement between NBS and LEAA in 1971, LESL is supplying the law enforcement community with technical reports, state-of-the-art surveys, user guidelines and national voluntary standards for equipment.

Current LESL contributions encompass communications equipment, security systems, investigative aids, protective equipment, police vehicles, court systems and other aspects of law enforcement. □

Police Computer: An Answer to Choked Channels

Rapid population growth accompanied by dramatic increases in crime seriously challenges the resources of many local police forces.

This is reflected in thinned-out patrols and congested police communication channels. For example, in a county not far from the nation's capital, the past five years have seen citizen telephone requests for assistance rising almost 2½ times, from 19,000 to 46,000 per year. The local police force had to cut preventive patrols drastically and it has been taking officers "an average of 19 to 21 minutes to respond to calls for help during busy hours."

Prevailing conditions have thus generated increasing interest around the country in mobile digital communica-

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NBS researchers are testing typical digital terminals for the Law Enforcement Assistance Administration

tions terminals. These devices sharply reduce police time on the air for each call. They are currently being tested at Boulder, Colorado, by the Commerce Department's National Bureau of Standards (NBS). The tests by the NBS Electromagnetics Division are sponsored by the Law Enforcement Assistance Administration through the NBS Law Enforcement Standards Laboratory.

Digital Device in Action

"A combination of good police work and the new mobile computer terminal today enabled two DeKalb County (Ga.) detectives to arrest two Virginia residents on a number of burglary charges of State and Federal consequences.

"During a routine check of automobile tags at a local motel, Detectives Cain and Stevens noted a new car with out-of-state license. Running a computer check with Vehicle Identification Number (VIN), the officers were able to determine that the auto license did not match the vehicle to which it was registered.

"At approximately 11 a.m. after 9 hours of surveillance, the officers approached the suspects and discovered the trunk to be filled with burglary tools and various items of household goods. Further investigation of the suspects' room revealed additional stolen property.

"The suspects . . . were taken to the DeKalb County Police Department.

"Chief Hand credits the arrest to the professional attitude of both detectives and their ability to utilize the new mobile computer terminal in an effective manner."—From a Public Safety Information release, DeKalb County Police Department, Decatur, Georgia.

New NBS Mercury Standards Will Aid Water Pollution Studies

MORE accurate measurements of mercury in natural waters will be possible as a result of two new standards developed by chemists at the National Bureau of Standards.

The Standard Reference Materials (SRM's) for mercury in water are the first nonradioactive water pollution standards offered by NBS. Mercury in water, concentrate (SRM 1641), and mercury in water, trace (SRM 1642), are certified for mercury at levels of 1.49 $\pm$ 0.05 micrograms per milliliter (part per million) and 1.18 $\pm$ 0.05 nanograms per milliliter (part per billion), respectively.

The SRM's will be used by both producers and users of secondary standards to check the quality of such standards. In addition, SRM 1641 may be used as a "spike" sample in "methods of addition" types of procedures. SRM 1642 may be used as received to test and evaluate methods for the measurement of mercury in natural waters at the part per billion level.

Mercury in water has been a source of public concern particularly since it was discovered that industrial mercury discharged into bodies of water is converted by certain bacteria in the bottom sediments to the more toxic methylmercury. Methylmercury more readily enters the food chain and passes from smaller to larger aquatic life.

In the 1950's 52 people in Minamata, Japan, died from eating fish contaminated with methylmercury In the United States large quantities of swordfish and canned tuna were temporarily taken off the market in 1970 and 1971 because they contained high levels of mercury.

In October 1973, the U.S. Environmental Protection Agency (EPA) published proposed criteria for water quality which recommended that water for livestock consumption contain no more than 1 microgram per milliliter; for fresh water aquatic life, no more than 0.2 nanogram per milliliter; and for public consumption, no more than 2 nanograms per liter. On March 14, 1975, EPA proposed a primary standard for mercury in drinking water of 2 nanograms per milliliter.

The mercury SRM's are certified in these ranges and their use should improve the comparability and accuracy of measurements of mercury in natural waters.

A major problem in the preparation of mercury solutions at or below the part per million level has been a lack of stability—the mercury concentration diminishes with time. NBS chemists Drs. Harry L. Rook and John R. Moody developed a technique to stabilize the solution by adding gold ions in concentrations 10 times that of mercury. The gold ion, in conjunction with the normal mineral acid present, is an effective stabilizer for at least 9 months, according to NBS studies. Research is continuing to determine the maximum length of time that the solutions remain stable.

SRM 1641 is issued as a unit of 6 ampoules, each containing 30 milliliters of solution. SRM 1642 is issued as a unit of 950 milliliters of solution. SRM 1641 costs $60 per unit; SRM 1642 costs $64 per unit. The SRM's may be purchased from the Office of Standard Reference Materials, Room B311, Chemistry Building, National Bureau of Standards, Washington, D.C. 20234. □

tremely difficult to work with, it required all the resources of 19th century metallurgical science plus a great deal of new research and trial-and-error before the problems of casting and shaping it were mastered. The metre prototype had the X-shape cross section designed for maximum stability by M. E. Tresca. The kilogram kept the same cylindrical shape of the kilogram of the Archives.

Several dozen duplicates of each prototype were made. One pair became the international prototype standards of length and mass and were kept in the custody of the International Bureau. Others were distributed for use as national standards to the signatory countries.

This work was approved by the first General Conference on Weights and Measures in 1889. Such a General Conference, made up of diplomatic representatives of the nations adhering to the Treaty, is held at least every 6 years. Its recommendations are carried out by an International Committee for Weights and Measures which, in turn, directs the activities of the International Bureau.

Thus by 1889 the Metric System had come of age. With the Treaty of the Metre it had made its formal entry on the international stage—and it had been adopted in 26 counties.

But even a nonmetric country like the United States found it to its advantage to support and participate in the work of the International Bureau and to maintain metric prototype standards. For one thing, the Metric System had become essential to U.S. scientists. For another, the metric standards were the most precise ones available; and so have been used as the basis for defining nonmetric units like the yard and pound.

The Metric System Today

Geographically, the Metric System has expanded about as far as it can go, with the exception of Brunei, Burma, Liberia, the United States and Yemen. Technically, the system has greatly expanded in scope and increased in refinement.

In 1899 the Metric System had only two base units. Now, to deal with a greatly broadened field of measurement, there are seven. A brief glance at these seven base units will give an inkling of how far we have come since then:

1. In 1960 the definition of the *metre* was radically changed, though its size remains essentially the same. It is now the length of a certain number of wavelengths of light emitted by krypton atoms. This fixes the metre with a precision of a few parts in a billion.

2. The international prototype *kilogram* still defines the unit of mass, but refinements of technique make it possible to compare kilogram masses with an uncertainty of only one part in 100 billion.

3. The *second*, metric unit of time, once the exclusive responsibility of the astronomer, was redefined in 1967 as a certain number of oscillations of a particular radiation of cesium atoms. Cesium standards fix the second with an uncertainty less than one part in ten thousand billion.

4. The metric unit of temperature, the *kelvin*, is a certain fraction of the interval between absolute zero and the triple point of water, which establishes the thermodynamic scale of temperature. The Celsius (formerly Centigrade) scale is obtained from this just by shifting the zero temperature from absolute zero to the freezing point of water.

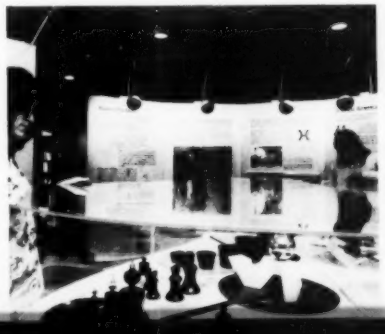
5. The *ampere*, metric unit of electric current, is defined in terms of the magnetic forces associated with it. All electrical and magnetic quantities can be defined in terms of the metre, kilogram, second and ampere.

6. Important in both industry and everyday life is the *candela*, metric unit of luminous intensity. It is the basis for measuring the brightness of all kinds of light sources.

7. Latest addition to the metric base units is the *mole*, unit of amount of substance. Formerly of primary interest to the chemist, it is now significant in all parts of physical science.

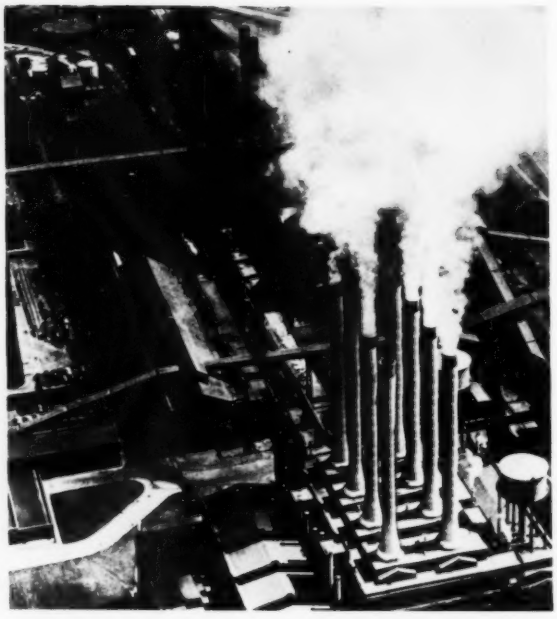
Thus, as new domains of knowledge open up, the Metric System adds new units, and it redefines older units—normally without altering their size—to give them greater precision. In this way, it manages to reconcile stability with flexibility, the capacity to grow with science and technology.

More than ever, the Metric System is living up to its formal name, adopted in 1960: *The International System of Units.* □



Visitors examine historical measurement standards on view in the NBS exhibit commemorating the 100th anniversary of the signing of the Treaty of the Metre.

POLLUTION *continued*



Accurate measurements of air pollutants emitted by industrial stacks and autos are necessary for fair and effective implementation of the Clean Air Amendments of 1970.

These SRM's for mobile source emission analysis are individually certified and are available at the following *nominal* concentrations:

SRM 1683—Nitric Oxide in Nitrogen, 50 ppm

SRM 1684—Nitric Oxide in Nitrogen, 100 ppm

SRM 1685—Nitric Oxide in Nitrogen, 250 ppm

SRM 1686—Nitric Oxide in Nitrogen, 500 ppm

SRM 1687—Nitric Oxide in Nitrogen, 1000 ppm

SRM 1665—Propane in Air, 2.8 ppm

SRM 1666—Propane in Air, 9.5 ppm

SRM 1667—Propane in Air, 48 ppm

SRM 1668—Propane in Air, 95 ppm

SRM 1669—Propane in Air, 475 ppm

SRM 1673—Carbon Dioxide in Nitrogen, 0.95 percent

SRM 1674—Carbon Dioxide in Nitrogen, 7.2 percent

SRM 1675—Carbon Dioxide in Nitrogen, 14.2 percent

SRM 1677—Carbon Monoxide in Nitrogen, 9.74 ppm

SRM 1678—Carbon Monoxide in Nitrogen, 47.1 ppm

SRM 1679—Carbon Monoxide in Nitrogen, 94.7 ppm

SRM 1680—Carbon Monoxide in Nitrogen, 484 ppm

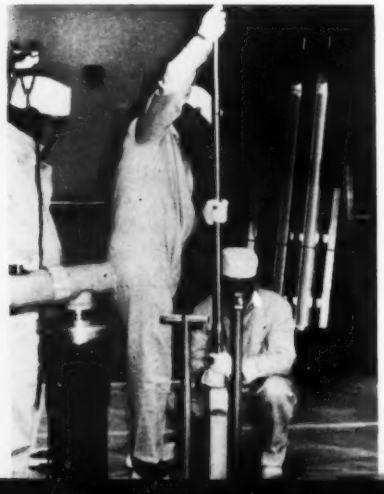
SRM 1681—Carbon Monoxide in Nitrogen, 957 ppm

These gases are supplied in cylinders with a delivered volume of 870 liters (31 cubic feet) at STP. The cylinders conform to the DOT 3AA-2015 specifications.

Additional information on the air pollution standards may be obtained from the Office of Standard Reference Materials, B311 Chemistry Building, NBS, Washington, D.C. 20234. □

X-RAYS *continued*

Nuclear fuel rods, such as those being loaded here into the NBS reactor, are routinely inspected for flaws with neutron radiography.



studies on neutron radiography applications.

Behind X-rays

At the present time, a number of problems remain to be solved before neutron radiography can become as commonplace as X-radiography. In fact, experts agree that applications of neutron radiography are running about 40 years behind X-radiography applications. One of the major problems is developing a "portable" source of neutrons—like the kinds of sources that exist for X-rays. Currently particle accelerators and nuclear reactors are the two major sources used—and they require enormous financial and physical investments.

Despite such obstacles, Berger says that he sees a time when neutron radiography is used routinely as a nondestructive inspection method. Indeed, portable neutron sources using Californium-252 have already been effectively demonstrated in field tests. Acceptance of the method in many industrial fields already indicates that neutron radiography holds great promise as one of the most intriguing and valuable nondestructive evaluation tools—not only for many high technology products, but for many consumer products as well. □

VOTING *continued*

should not be used for any other purpose. In addition, the support software should be used only for vote tallying.

To assure public confidence in the system, the public should know that these steps have been taken to assure the accuracy and security of the vote-tallying process. The voter also should have confidence that the rearrangement of candidates and issues on the sample ballot matches the arrangement he will find at the polls.

New Systems

Since many voters may have difficulty in dealing correctly with complex devices, Saltman points out that new computer voting systems should be designed for the ease of the user. In developing new systems, it is important to consider how individuals react to specific types of equipment, what kinds of errors are made and how different voting systems affect voter dropoff (the tendency of voters not to vote for candidates running for lower level offices). Ballot design, including the question of how much the first candidate listed benefits, if at all, also deserves attention.

Remote-voting systems, involving consoles and telecommunications which maximize voter convenience and increase voter participation, should also be considered, according to Saltman's report. Election officials considering such systems should be aware, however, of the potential security problem of identification of voters using these systems. To help election administrators cope with this new technology in computerized voting, Saltman suggests that additional technical expertise at the state level may be needed to provide the technical guidance needed at the local level.

When a computerized election encounters difficulties, Saltman says, the public loses confidence in the results. An efficient computerized election is one that is thoroughly and extensively planned in advance. □

OZONE *continued*

ured the concentration of chlorofluorocarbons in the atmosphere, and no one gets ideas in the total absence of data."

If further study proves scientists' predictions to be true, what can be done? "There are alternative ways to propel hair spray and other products," said Garvin. "You can use a simple spray bottle that relies on fingertip pressure instead of a propellant gas—there's little pollution in a fingertip."

"Chemists can also develop alternative propellants," he noted. "But, in that event, each proposed propellant should be assessed for its environmental impact. If the situation becomes clearly dangerous, it may be necessary to control the use of propellant gases and other compounds.

"However," Garvin added, "at present we do not have sufficient hard information upon which to base such controls. A lot of research still must be done." □

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